

Fossil Mammoths from Santa Cruz Island, California

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Mammoth remains on Santa Cruz Island, one of the four Northern Channel Islands of California, are very sparse, in marked contrast to those reported from Santa Rosa and San Miguel Islands of the same island group. A probable major reason for this scarcity is that Quaternary deposits are greatly restricted on Santa Cruz Island. It is proposed, contrary to popular opinion, that fossils found on Santa Cruz Island were derived from animals which died on the island, and were not transported there by humans. Reasons for this conclusion are that the size and geological context of the fossils are similar to those of the largest mammoth fossils of Santa Rosa Island, and that, in spite of extensive investigations by many persons, mammoth remains have not been found in middens, either on the islands or on the adjacent mainland.

INTRODUCTION

The Northern Channel Islands are the westward extension of the province Anacapa, which is identified with the mainland Transverse Ranges (Reed and Hollister, 1936). These ranges run east-west, rather than north-south as in the case of the other California ranges. On the mainland, Anacapa includes the east-west-trending Santa Ynez Mountains, the Ventura Basin, the Simi Valley, and the Santa Monica Mountains. At sea the province includes, from east to west, the islands of Anacapa (Las Anacapas), Santa Cruz, Santa Rosa, and San Miguel. This subject is reviewed by Weaver and Doerner (1967), Valentine and Lipps (1967), Vedder and Howell (1980), and Johnson (1978, 1983).

That the Northern Channel Islands were not connected to the mainland by a land bridge during the Quaternary is well documented (Savage, 1967; Johnson, 1978, 1983; Junger and Johnson, 1980; Wenner

and Johnson, 1980) and is now a favored concept. However, debate on this question continues (e.g., Azzaroli, 1981; Berger, 1982).

The sizes and shapes of all the offshore islands of Southern California have fluctuated greatly during the glaciations, interglaciations, and tectonic events of the last 128,000 yr (Orr, 1968; Johnson, 1983). For example, Cortes Island (now Cortes Bank) emerged, varied in dimensions, and then submerged; San Nicolas Island increased in size for a time to achieve an area roughly equivalent to that of today's Santa Monica Mountains; and, starting about 18,000 yr B.P., the large island Santarosae (Orr, 1968) became partially submerged as the Wisconsin glaciation waned. This submergence evolved the four Northern Channel Islands into their present forms about 2000 yr B.P.

The Quaternary sediments on the southwestern portion of Santa Cruz Island were apparently contiguous with the fossil-mammoth-containing sediments of Santa Rosa Island until separated by submergence. These sediments are exposed as several noncontiguous areas adjacent to the shore-

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line on Santa Cruz in the Christy Ranch area and in parts of nearby southwestern canyons and their tributaries (Fig. 1). Extensive erosion, exacerbated over the last century by feral sheep and pigs, occurs over the whole island during annual winter storms (Power, 1980). This erosion and associated sedimentation has both exposed and buried large areas of sediments, thus producing new opportunities each year for finding fossils. The amount of sediment moved can be extraordinary. For example, we have seen as much as 10 m of alluvium deposited in a single storm, and have found a sheep rib that had been buried and reexposed in the bottom wall of a gulch cut through some 16 m of stratified sea-cliff sediments at the beach near Christy Ranch.

The only fossil vertebrates that have been recorded on Santa Cruz Island are the mammoth remains reported here. The paucity of vertebrate fossils on all the Northern Channel Islands contrasts markedly with the contemporaneous Quaternary fossil record on the mainland and provides a strong argument against the existence of a Quaternary land bridge between the islands and the continent. Savage (1967) and Wenner and Johnson (1980) discuss in de-

tail both the scarcity of island fossils and the depauperate nature of the recent fauna of the islands.

We note some additions to the mammalian fossil record of the islands. As stated in his extensive study of the Island Fox, Collins (1982) has found, in the Santa Barbara Museum of Natural History, Orr's (1968, p. 59) Island Fox (*Urocyon littoralis*) fossil skull that was believed lost in transit from Santa Rosa Island to the Museum; Walker (1980) has shown that the endemic extinct "giant" deer mouse, *Peromyscus nesodytes*, formerly known only from Santa Rosa Island, was alive on San Miguel as recently as 2000 yr B.P., as were the spotted skunk (*Spilogale gracilis*) and ornate shrew (*Sorex ornates*); and Guthrie (1980) described remains of the extinct vampire bat, *Desmodus stocki*, associated with those of the deer mouse described by Walker. This bat, first recorded from Mexico by Cushing (1945), ranged widely over North America during the Pleistocene. A "possible horse hoof" fossil collected by R. C. Olson and now in the Los Angeles County Museum of Natural History was reidentified for us, through the courtesy of T. Downs and J. Dock of that institution,

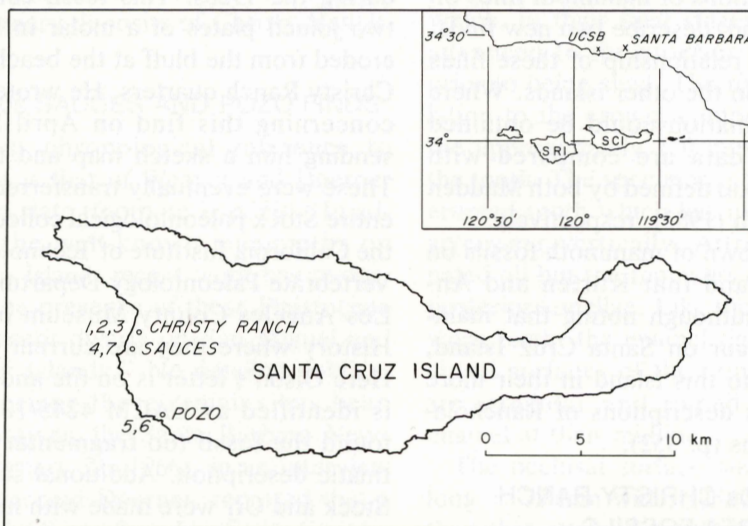


FIG. 1. Map of Santa Cruz Island and (inset) its relationship to Santa Barbara, California, and the University of California, Santa Barbara campus. Numbers refer to specific localities where mammoth fossils have been found in Quaternary deposits, as described in the text.

as plant material (Janet Dock, personal communication, 1982).

The island mammoth fossils were first described as the dwarf species *Mammuthus exilis* by Stock and Furlong (1928) and have since been found on San Nicolas, Santa Rosa, and San Miguel Islands. While the San Nicolas find consists of only a single molar (Vedder and Norris, 1963), those found on Santa Rosa and San Miguel Island are numerous. Orr (1968), who worked for many years on Santa Rosa Island, discussed the island mammoths in detail; Azaroli (1981), Johnson (1981, 1983), Junger and Johnson (1980), and Wenner and Johnson (1980) in the context of biogeography also have made detailed studies of the island mammoths; Madden (1977, 1981a, b, 1982) has extensively examined their systematics; and Roth (1982) has made a comprehensive study of the size, shape, development, and evolution of the dwarf mammoth. Letters of Madden (1981b) and Johnson (1981) provide additional information, as does that of Azaroli cited above. Berger (1980, 1982) describes his ongoing research on Santa Rosa Island relative to the possibility of the concurrent existence of early men and mammoths.

In this paper we assemble, for the first time, all descriptions of mammoth finds on Santa Cruz Island, describe two new finds, and discuss the relationship of these finds to those made on the other islands. Where sufficient information could be obtained from a tooth, data are compared with groupings (or taxa) defined by both Madden (1981a) and Roth (1982), respectively.

So little is known of mammoth fossils on Santa Cruz Island that Kurtén and Anderson (1980), although noting that mammoth fossils occur on Santa Cruz Island, omit reference to this island in their more detailed species descriptions of Rancholabrean mammoths (p. 352).

THE 1920s CHRISTY RANCH AREA FOSSILS

The first account of mammoth fossils on Santa Cruz Island concerns a discovery by

D. B. Rogers, archeologist at the Santa Barbara Museum of Natural History, who "found two teeth in an Indian burial, and he assumed, as did Stock, that these had been carried from Santa Rosa" (Orr, 1968, p. 36). A letter from Orr to R. C. Olson (see below) dated January 31, 1966 (Santa Barbara Museum of Natural History archives) refers these to the outcrop of Pleistocene sediments near Christy Ranch, Santa Cruz Island (Fig. 1), and affirms that "D. B. Rogers found two teeth in an Indian grave there which could have come from these beds, although I have been unable to find any." Rogers does not refer to this find in this 1929 book which covers his research to February 1927. We assume that the teeth were discovered later, for his book describes all significant artifacts found by him. However, we have not been able to locate the specimens or to find reference to them in his subsequent field notes in the SBMNH archives. Starting with the Rogers' finds, listed as 1 and 2, we will continue to number additional finds as shown in the text and on Figure 1.

R. C. Olson, anthropologist at the University of California, Berkeley, made the other (also unpublished) discovery of a mammoth fossil (3) on Santa Cruz Island during the 1920s. This fossil consisted of two joined plates of a molar in loose soil eroded from the bluff at the beach near the Christy Ranch quarters. He wrote to Stock concerning this find on April 22, 1929, sending him a sketch map and the fossil. These were eventually transferred with the entire Stock paleontological collection from the California Institute of Technology to the Vertebrate Paleontology Department of the Los Angeles County Museum of Natural History where they are currently housed. Here Olson's letter is on file and the fossil is identified as LACM 4248/107295. We found the fossil too fragmentary for systematic description. Additional searches by Stock and Orr were made with negative results (Santa Barbara Museum of Natural History Archives).

Olson also recognized a Pleistocene tree

locality on his 1927 trip and called it to the attention of Chaney and Mason, paleobotanists at the University of California, Berkeley. This led to their paper (Chaney and Mason, 1934) describing the flora. It appears, therefore, that their comment, "Fragmentary remains of *Elephas columbi* (?) have been found on Santa Cruz Island a few miles north of the Willow Creek locality in alluvium which is undoubtedly of the same age as the Santa Cruz Island formation," refers to the Olson mammoth fossil. (N. B.: "Willow Creek" refers to Cañada de los Sauces del Oeste, most commonly referred to as "Sauces" (Fig. 1), and it is not to be confused with Willows Canyon on the Southeast side of the island.)

Olson's discovery also would seem to be the basis for Stock's comment (1935, p. 210) that "two fragmentary enamel plates of an elephantic tooth were found lying on an eroded surface of Quaternary deposits exposed along the ocean front a mile or more away from the locality where the [Chaney and Mason, 1934] plant specimens occurred." The plates also seem to be the basis for the somewhat misplaced X locality mark on the Santa Cruz Island figures in Stock's 1935 and 1936 papers. This mark is too far to the northwest and so is beyond the Quaternary deposits of Christy Ranch.

THE 1960s SAUCES AND POZO FINDS

The next chronological reference to mammoths is that of Weaver and Doerner (1967) who state (footnote 2, p. 89) "In addition to the well-known mammoths on Santa Rosa Island, recent work has re-documented the presence of these Pleistocene and sub-recent dwarfs on San Miguel and Santa Cruz Islands." No detailed publication concerning these remains has been made. However, the Santa Barbara News Press (February 21, 1966), in an interview with Weaver and Doerner, reported that a molar tooth (4) was found on Santa Cruz by

Lloyd Edwards, a geology student working with Weaver and Doerner. It also noted that a mammoth tusk (now in the possession of the Channel Islands National Park) was found by Weaver and Doerner on San Miguel Island. The molar shown in the accompanying News Press photograph was not the island tooth but that of a mainland mammoth, used as a "prop" by the reporter (D. P. Doerner, personal communication, 1979). Orr (1968, p. 36) referred to this discovery without citation, as follows: "Recently a third tooth [the other two teeth being those found by Rogers] has been found by members of the geology class of the University of California at Santa Barbara, in Cañada de los Sauces del Oeste, probably in the same area where Chaney and Mason found the fossil plants." D. W. Weaver (personal communication, 1981) has confirmed Orr's statement, adding that the tooth was in alluvium on the floor of the same stream bed section of Sauces Canyon as the Chaney and Mason 14,000-yr-old fossil plants. The specimen is now in the Santa Barbara Museum of Natural History Vertebrate Paleontology Collection (Paleontology Field Number: SBMNH, 1-68). The tooth appears to be the fragmentary posterior end of a first or second mandibular molar (M_1 or M_2), similar to teeth which, in their final stages of wear, have advanced to the anterior part of the jaw prior to being shed. The root is long in relation to the crown, comprising 90 mm of the approximately 150 mm total height of the tooth. The specimen is therefore a fully erupted tooth which has undergone extensive wear vertically. Attrition has eliminated all but the remnants of the five most posterior lamellae. Like those of extremely worn teeth, the enamel figures on the occlusal surfaces of the remaining lamellae are irregular and joined by bridges of enamel at their midline.

The occlusal surface measures 100 mm long \times 75 mm wide. This width is greater than that attained by the first three serial

categories of teeth in the mainland mammoth [cf. Roth (1982) for a detailed discussion of the complexities involved in establishing the numbers and homologies among the teeth of the Elephantidae], and it therefore characterizes the tooth as an M_1 , M_2 , or M_3 . Unlike the third (i.e., last) molar, the tooth has a blunt posterior end, which suggests the impression of another tooth immediately posterior to it. The specimen is, thus, most probably an M_1 or M_2 from an individual whose size was comparable to that of a mainland mammoth.

Another mammoth fossil (5), unnoted in publications, was examined by us in the Department of Geological Sciences, University of California, Santa Barbara. This also was found by Edwards in the 1960s, its label stating that it was identified from photographs by C. Madden, then of the University of Colorado Museum, as a piece (about 30 cm long) of the right femur of a mammoth. The piece was too fragmentary for assessment of its growth stage or for useful measurement. The label also stated that it came from a notch in the Pozo stream terrace wall (Fig. 1) where it was embedded in alluvial gravel. Some sand and gravel were observed by us to be cemented to it, indicating that it had been washed to its present site from older alluvium. These 1960 fossils account for the mammoth remains reported by Weaver and Doerner (1967).

There are rumors of other fragmentary mammoth fossils having been found about this time, but we have not been able to substantiate them sufficiently for recording. The fact that during that period geology students worked intensively on Santa Cruz Island supports the observation that mammoth fossils are very scarce there in comparison with Santa Rosa and San Miguel Islands.

THE 1980 POZO MOLAR

A series of searches over the southwestern portion of Santa Cruz Island, ini-

tiated by us in 1979, led to Pozo Canyon. Here on May 29, 1980, Noble found the molar of a mammoth (6) on the surface near the center of the dry stream bed of the canyon about 1000 m upstream from the beach (Cushing *et al.*, 1981).

The specimen (Paleontology Field Number: SBMNH, 1-80) is a nearly complete left maxillary cheek tooth bearing 19 lamellae. One or more additional anterior lamellae have been lost in wear, but the posterior end of the tooth is apparently intact. The enamel figures from eleven lamellae are exposed by wear on the occlusal surface, which measures 185 mm longitudinally. The length of the entire tooth, measured with caliper jaws parallel laterally to the average orientation of lamellae, is approximately 265 mm, the greatest height is 215 mm, the maximum breadth across a single lamella is 91 mm, and the enamel thickness is approximately 2 mm.

The tooth is larger in each of its dimensions than most maxillary teeth from Santa Rosa Island in the collections of the Los Angeles County Museum or the Santa Barbara Museum of Natural History. In length, width, and number of lamellae, it falls within the range of variability described for an M^2 or M^3 of *M. columbi* from the mainland (Roth, 1982). This is equivalent in size to a small number of specimens [SBMNH 354 SBMNH 221 28/48, LACM (CIT) 637, LACM 71149] which Madden (1981a, b) designated as *Mammuthus columbi*. The tapered posterior end of the tooth suggests that it was the last of its series, i.e., an M^3 .

THE 1982 SAUCES MOLAR

Noble, during another search by us, found part of a molar (7) on June 26, 1982, in Saucos Canyon, again in the Chaney and Mason fossil flora locality. This specimen was partially exposed 4.5 m above stream level on the west side of the stream bank. It was 530 m from the beach and had been redeposited from an unknown locality upstream, as shown by its being partially ce-

mented with alluvial sand in contrast to the looser soil in which it was embedded. Don L. Johnson (personal communication, 1982) subsequently confirmed our opinion that the site was a secondary deposition of upstream soil.

The fragment (Paleontology Field Number: SBMNH, 1-82) represents the anteriormost portion of a right mandibular cheek tooth in its initial stages of eruption. It comprises five and a half plates, the most anterior of which is reduced (joined to the second midway between occlusal and ventral surfaces and entering the root with it), and the last of which is represented by its anterior half only, having been sheared vertically with the breakage of the tooth. The enamel of the lamellae is partially exposed through the cementum on the lingual and lateral aspects of the tooth. The cementum sheath of the root has been lost but the lamellae are intact, with only the most ventral tips of the enamel plates missing. Wear on the occlusal surface has not proceeded beyond the fourth plate.

The fragment is approximately 72 mm long, its maximum height is about 115 mm, and the maximum width is 61 mm. Such a width would rank it among the larger specimens from Santa Rosa Island. When intact, the tooth would have been equivalent to or larger than the third tooth in succession of the mainland mammoths, i.e., it was the last deciduous premolar, an M_1 , M_2 , or M_3 (Roth, 1982). According to Madden's (1981a) criteria, the height and width of the tooth fall within the range of M_3 for *M. exilis*, while its width (but not height) would permit an identification of M_2 . For *M. columbi* these dimensions fall within Madden's (1981a) ranges for M_1 ; M_2 is another possible but less likely alternative.

DISCUSSION

Considering the lack of consensus in taxonomic nomenclature among systematic studies of mammoths [discussed in more detail in Roth (1982)], it is premature to allocate the specimens described here into

one or another species of *Mammuthus*. As Kurtén and Anderson (1980, p. 351) have remarked, "species delineation in mammoths is not sharp." A better understanding of variability in the recent species of elephants, particularly *Elephas maximus*, is essential if species-level differences among fossil mammoths are to be assessed properly (Roth, 1982). Nonetheless, useful comparisons can be made. Regardless of the systematic identity of specimens from Santa Cruz Island, one can ask whether they most nearly resemble fossils found on the other Channel Islands, or those associated with the mainland.

In an extensive comparison of island and mainland mammoths made recently by one of us (Roth, 1982), the terms "*Mammuthus exilis*" and "*Mammuthus columbi*" were used provisionally to designate specimens associated geographically with the islands and the mainland, respectively. The mainland group *M. columbi* was intentionally defined quite broadly; specimens were eliminated from consideration only if there were striking differences in the teeth [for a more detailed explanation, see Roth (1982)]. Using allometric relationships she established for lengths of limb bones in modern elephants, Roth estimated the shoulder heights of physically mature mammoths (epiphyses fused) from Santa Rosa Island represented in the SBMNH and LACM collections to be between 105 and 215 cm, with one extraordinarily large humerus [numbered both SBMNH 344 and 23603/50 and considered by Madden (1981b) to be *M. columbi*] extending the range to 235 cm. These estimates essentially confirm those given earlier by Orr (1968), who judged the height of adult mammoths on Santa Rosa to have been between 4 and 8 ft (1.2 and 2.4 m) with a mode at 6 ft (1.8 m). Although most known island specimens fall outside the size range for the mainland samples of mammoths (Roth, 1982), there is clearly some overlap in sizes between mainland and island forms. The large humerus from Santa Rosa Island men-

tioned above, for example, is identical in size (894 cm between proximal and distal articular surfaces) with the Cleveland Museum of Natural History's specimen CMNH 10429, a *M. columbi* from Colorado.

The three mammoth specimens from Santa Cruz Island newly described here (numbers 4, 6, 7) clearly are within the range of size of mammoths from the adjacent mainland and so cannot be considered dwarfed. The same is true of a large maxillary molar (SBMNH Paleontology Field Number 1-81) found by Noble on Santa Rosa Island in 1981 (Roth, 1982, p. 23).

Of the seven separate finds of mammoth fossils that have been made in the Quaternary areas on the southwest end of Santa Cruz Island, two were found partially embedded in alluvium but had some cemented sand and gravel on them, indicating they were eroded out of older localities and redeposited. As already noted, redeposition of alluvium has been recurrent and extensive since the advent of feral sheep and pigs on the island.

These finds lead to reconsideration of the suggestions that mammoth fossils reached San Nicolas (Vedder and Norris, 1963) and Santa Cruz (Orr, 1968, p. 36) Islands by human transport, during either prehistoric or historic times. Unfortunately an adequate description of the original circumstance of the San Nicolas find is lacking. However, in contrast to the opinion of Vedder and Norris, the relatively large size of the molar does not now seem to preclude its origin from an individual that died on the island. Moreover, the much greater extent of San Nicolas during part of the Quaternary (Johnson, 1983) could have made this island a larger and more accessible target for landings and possible colonization by mammoths than it would be today.

We also believe, contrary to the citation from Orr quoted above, that the fossils of Santa Cruz Island were not transported from the mainland by humans, but originated from mammoths that died on Santa

Cruz or the equivalent portion of Santa Rosae. In addition to the absence of any midden material association with our finds, we have two reasons for this belief. First, although of very limited area, the Quaternary sediments where all the mammoth fossils have been found very closely resemble those of Santa Rosa Island, where such sediments are so extensive and contain so many mammoth remains that any thought of human transport is out of the question.

The second argument against human transport is even more compelling. Excepting Orr's enigmatic report about Rogers cited above, no one to our knowledge has recorded mammoth remains among the many and varied artifacts, shells, and animal bones recovered from middens on the adjacent mainland, or on any of the Northern Channel Islands (e.g., Rogers, 1929; Fisher, 1930a, b; Orr, 1968; Glassow, 1980). This point is especially interesting on Santa Rosa and San Miguel Islands, where mammoth remains are so abundant that they could not have escaped the attention of aborigines. Therefore, fossils do not seem to have been an item valued by the Indians and thus were not transported for trade or other reasons. In fact, mammoth fossils may have been awesome to the Chumash. A Chumash legend has been called to our attention by Travis Hudson, Curator of Anthropology, Santa Barbara Museum of Natural History. The story, which concerns a mythological flood (Blackburn, 1975, pp. 94-95), concludes as follows: "Maria has seen rocks in the mountains that are the exact shape of human arms and hands: they are the remains of the people who died in the flood. Those first people, the molmog?iku were very tall. They used to wade across the channel without needing boats, taking chia (a sage seed) and acorns and other things to the islanders in carrying nets. The very old men told Maria that people had found bones on Santa Rosa Island at Mikiw which were human but which were twelve yards long." One should keep in mind that tales

obtained from the last survivors of aboriginal populations can be greatly modified by European contacts. For example, the Chumash had had long exposure to the biblical account of the Flood.

Our conclusion therefore, is that mammoth fossils, while scarce, are as indigenous to Santa Cruz Island as they are to Santa Rosa and San Miguel and that additional finds will continue to be made on Santa Cruz Island to substantiate this conclusion even more fully. We also believe that, because of present extreme erosion and probable past erosion, some of which may have been induced by the mammoths themselves (Johnson, 1978), it is unlikely that fossils of mammoths will be found at the original sites of death.

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